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DTM-9000 ADAPTIVE DIGITAL MODEM AN/TRC-170 RADIO INTERFACE TESTS

By

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A test program was conducted during July and August 1984 to determine the feasibility of using components of the AN/TRC-170 radios with the DTM-9000 Adaptive Digital Troposcatter Modem. The first part of the effort consisted of system Bit Error Rate (BER) tests with and without the klystron power amplifier. The second part consisted of verifying the linearity and bandwidth parameters of the individual AN/TRC-170 radio components (upconverter/downconverter, frequency synthesizer, etc.). Details of the program, together with the analyses of the data, are reported in this document.

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EXECUTIVE SUMMARY

Defense Communication System (DCS) links in Europe, both line-of-sight (LOS) and troposcatter, are being upgraded and converted to digital links through the Digital European Backbone (DEB) program. The troposcatter digital upgrade is being accomplished through a combination of modification of some existing on-site radio components and acquisition of some off-the-shelf or modified off-the-shelf radio components. The digital upgrade calls for the acquisition of the MD-1208/G digital adaptive modem, which is an improved version of the DTM-9000 modem. In order to ascertain the compatibility of various off-the-shelf components, a test program was undertaken for a functional troposcatter terminal configuration. This configuration consisted of a DTM-9000 adaptive modem and selected components of the full scale engineering development (FSED) version of the AN/TRC-170, i.e., upconverter, downconverter, frequency synthesizer, and high power amplifier (HPA) of AN/TRC-170(V)1.

The performance of the test configuration was evaluated using a simulated digital mission bit stream and a troposcatter path simulator (S-261C). Troposcatter link performance was evaluated by comparing the measured average BER with the mean E_b/N_o for four multipath configurations. A troposcatter channel is modeled as a linear time varying channel whose average multipath properties are given by the delay power profiles. The troposcatter channel parameters were varied from flat fading ($2\sigma/\tau = 0$) to frequency selective fading of $2\sigma/\tau = 1.35$, where 2σ is the multipath delay spread and τ is the symbol duration (200 nanoseconds for 10 Mbps QPSK data rate).

The BER performance tests indicated that the upconverter, downconverter, and the HPAs for the FSED version of the AN/TRC-170 terminal appear to be usable in a digital troposcatter implementation up to a 9.696 Mbps mission bit stream data rate with the DTM-9000 type of adaptive modem. These radio components only slightly degraded the BER performance (1 to 2 dB, depending on 2σ multipath dispersion) when compared to the modem back-to-back performance.

The VA-908R klystron used in the AN/TRC-170(V)1 terminal, though rated for 8.0 kW (saturated), cannot, however, be used at this saturated power because of degradation effects evidenced by the measured bit errors because of nonlinear response of the klystron. The VA-908R transfer characteristics exhibit nonlinear response above 5.0 kW. The suggested usable output power for this klystron, using the AN/TRC-170 high voltage power supply system (HVPS), is 3 kW, which is the 1 dB compression point.

It would be desirable to perform tests to accurately determine the modem performance with the production-type AN/TRC-170 radio components, since design modifications have been made in the equipment. Test results obtained from the production components will yield a more accurate assessment of the usability and the system constraints when interfacing the DTM-9000 modem with the AN/TRC-170 radio equipment.

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SECTION 1

INTRODUCTION

The current Defense Communications System (DCS) analog troposcatter link across the North Sea connecting Martlesham Heath, UK, to Hoek Van Holland, NL (Link T0110), is scheduled to be upgraded with a digital link and rerouted from Martlesham Heath to Woensdrecht, NL (Link T011X), as part of the Digital European Backbone (DEB) program. The implementation plan provides for the use of a new modem (MD-1208/G digital adaptive modem, currently in acquisition) and off-the-shelf or modified, off-the-shelf radio components, i.e., upconverters, downconverters, frequency synthesizers, high power amplifiers, etc.). A functional configuration is shown in figure 1.1. A test program was generated to ascertain the compatibility of an adaptive digital modem and selected off-the-shelf troposcatter radio components.

The DTM-9000 digital adaptive modem was selected for the testing because its performance and electrical interface characteristics are similar to those of the MD-1208/G and because it could be made available for the tests. The MD-1208/G is an enhanced version of the DTM-9000. Low-level radio components and high power amplifiers (HPA) of the FSED version of the AN/TRC-170 troposcatter radio terminal, AN/TRC-170(V)1, were made available for the tests.

Tests were conducted at Fort Huachuca, Arizona, during July and August 1984 using the DTM-9000 modem, the AN/TRC-170(V)1 radio components, and a model S-261C troposcatter path simulator.

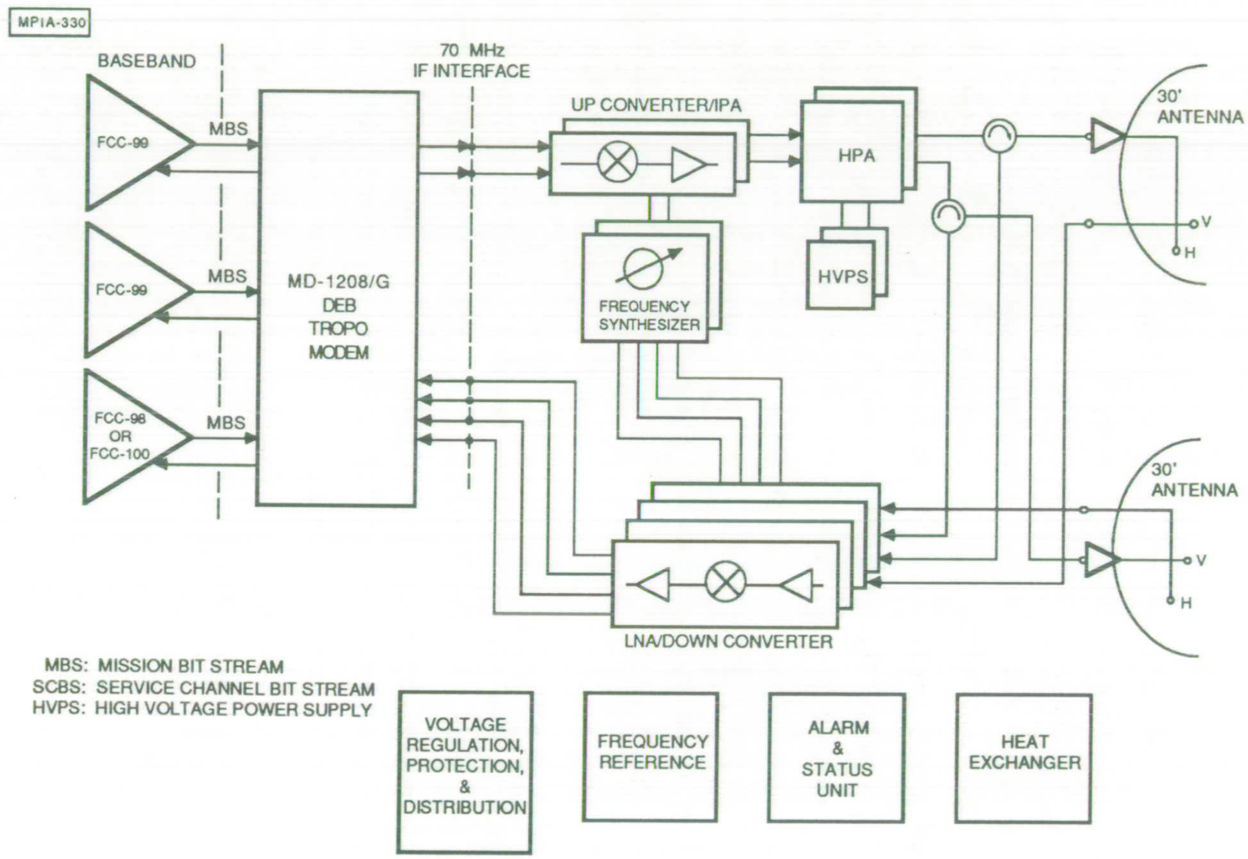

Figure 1.1. DEB Tropo North Sea Link Terminal (Functional Configuration)

Bit error rate (BER) tests were performed for various test configurations: modem loopback, upconverter/downconverter loopback, and HPA loopback with the HPA terminated into a dummy load. A total of 24 BER tests were performed during the limited time period. In addition, tests were performed on the low-level radio components to evaluate their linearity and bandwidth characteristics.

SECTION 2

TEST OVERVIEW

MITRE personnel in Fort Huachuca and MITRE personnel in Bedford were responsible for planning and executing these tests. Two DTM-9000 modems, one for the transmit portion of the link, the other for the receive portion, were made available by Rome Air Development Center (RADC). RADC also provided the use of troposcatter path simulator (Model S-261C), which was used to simulate the troposcatter path characteristics. Two troposcatter terminals, an FSED AN/TRC-170(V)1 for the transmitting portion and another FSED AN/TRC-170(V)3 for the receiving portion, were made available on short notice by Electronic Systems Division (ESD) during the testing.

The test program consisted of two phases:

1. Installation and integration
2. Bit Error Rate tests
3. Radio component tests

2.1 TEST OBJECTIVES

The overall objective of the testing was to ascertain interface compatibility between the modem and the radio equipment. A secondary objective was to evaluate the performance of the radio equipment for potential use in the DEB Troposcatter North Sea Link upgrade. Specific objectives included the following:

1. Determine BER performance when the link is subjected to various multipath profiles (using the S-261C simulator).

2. Determine BER performance when using the VA-908R C-band klystron High Power Amplifier and the S-261C simulator.

3. Determine the bandwidth of the AN/TRC-170 radio components. These components include the upconverters, downconverters, and associated filters.

4. Determine phase distortion (phase response) through the AN/TRC-170 rf modules.

5. Determine the linearity characteristics and dynamic range of the upconverters and downconverters.

6. Determine the spurious signal response at the intermediate power amplifier (IPA) and at the output of the frequency synthesizer.

2.2 TEST CONFIGURATION

The test configuration used for these tests is shown in figure 2.1.

A Hewlett-Packard HP3780A test set pattern generator was used to simulate the mission bit stream data rate of 9.696 Mbps. The data was differentially encoded and quadriphase shift-keyed (modulated) by the DTM-9000 on a 70 MHz intermediate frequency (IF) carrier. The Rubidium Standard (EFRATOM clock) of the AN/TRC-170(V)1 radio provided the 10 MHz standard clock for the DTM-9000 and the frequency synthesizers. Since the DTM-9000 modem requires a 5 MHz clock and

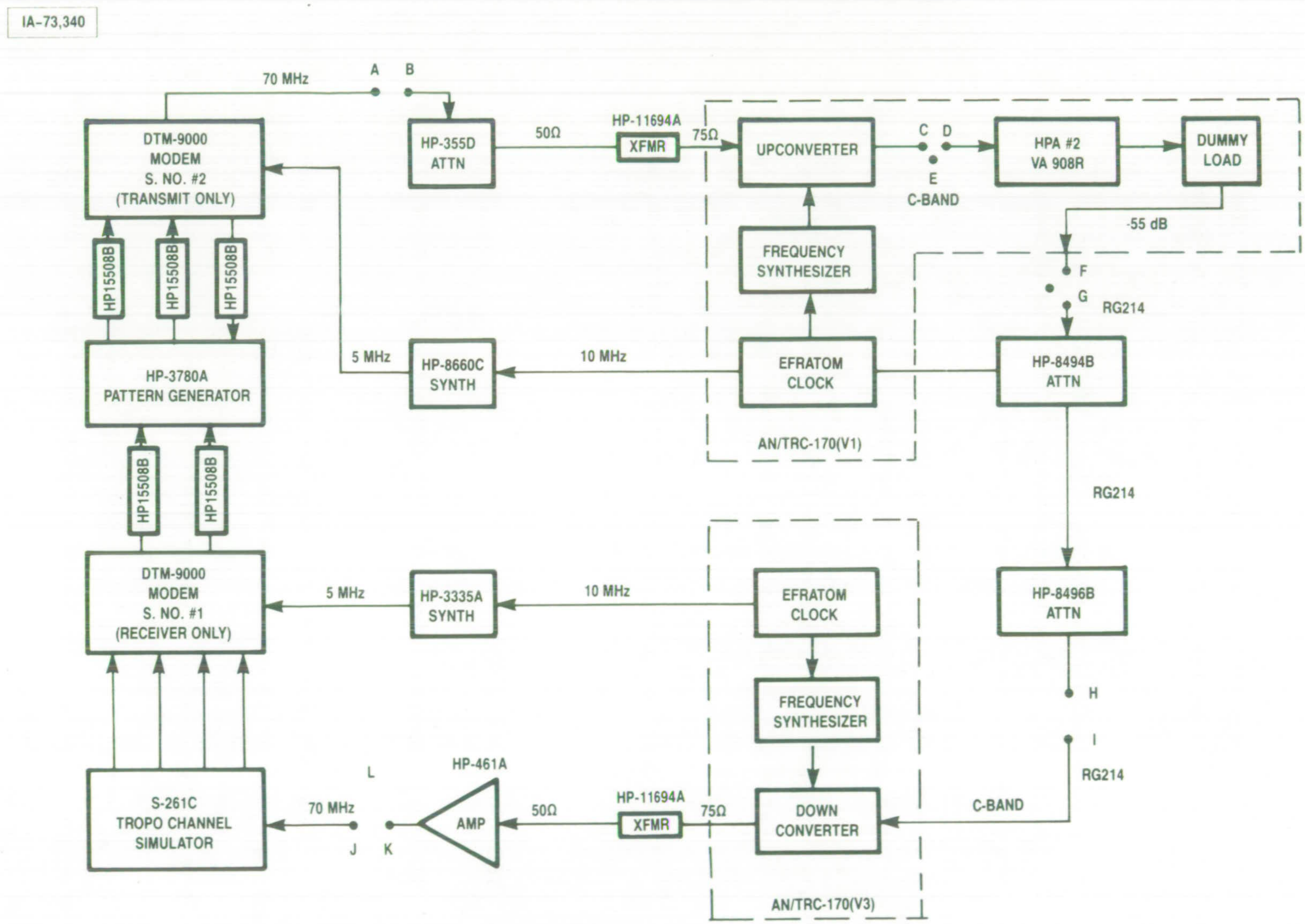

Figure 2.1. Functional Test Configuration

the EFRATOM clock provides a 10 MHz clock, additional synthesizers (HP8660C, HP3335A) locked to the reference standards were used to maintain the standard clock stability. For most of the tests, the transmit portion of the AN/TRC-170(V)1 was used to transmit and another shelter containing an AN/TRC-170(V)3 was used to receive the signal. General purpose test equipment such as impedance matching transformers, attenuators, and IF amplifiers were used for signal conditioning and matching purposes. The HP3780A pattern generator measured the bit error rates between the receive and transmit bit streams.

A Signatron troposcatter path simulator (Model S-261C) was used to simulate the multipath profiles. A block diagram of the S-261C simulator is presented in figure 2.2. The settings on the tap group attenuators, together with the tap spacing, provided the multipath dispersion of interest.

The attenuator settings and the tap spacings (which result in four multipath profiles) are shown in table 2-1. The test equipment used in these tests is presented in table 2-2.

Modem/Modem loopback tests (test configuration appears in figure 2.3) were performed to establish a baseline performance criteria. Tests were run for four multipath profiles with delay multipath spreads (2σ) of 0, 41.3, 153.2, and 270 nanoseconds. Separate time standards were used at the two terminals to include the effects of using independent clocks. The fade rate for these tests was 10 Hz.

Tests were performed (using the test configuration of figure 2.4) to evaluate the effect of low-level radio components (upconverter/downconverter) on the modem loopback configuration. The

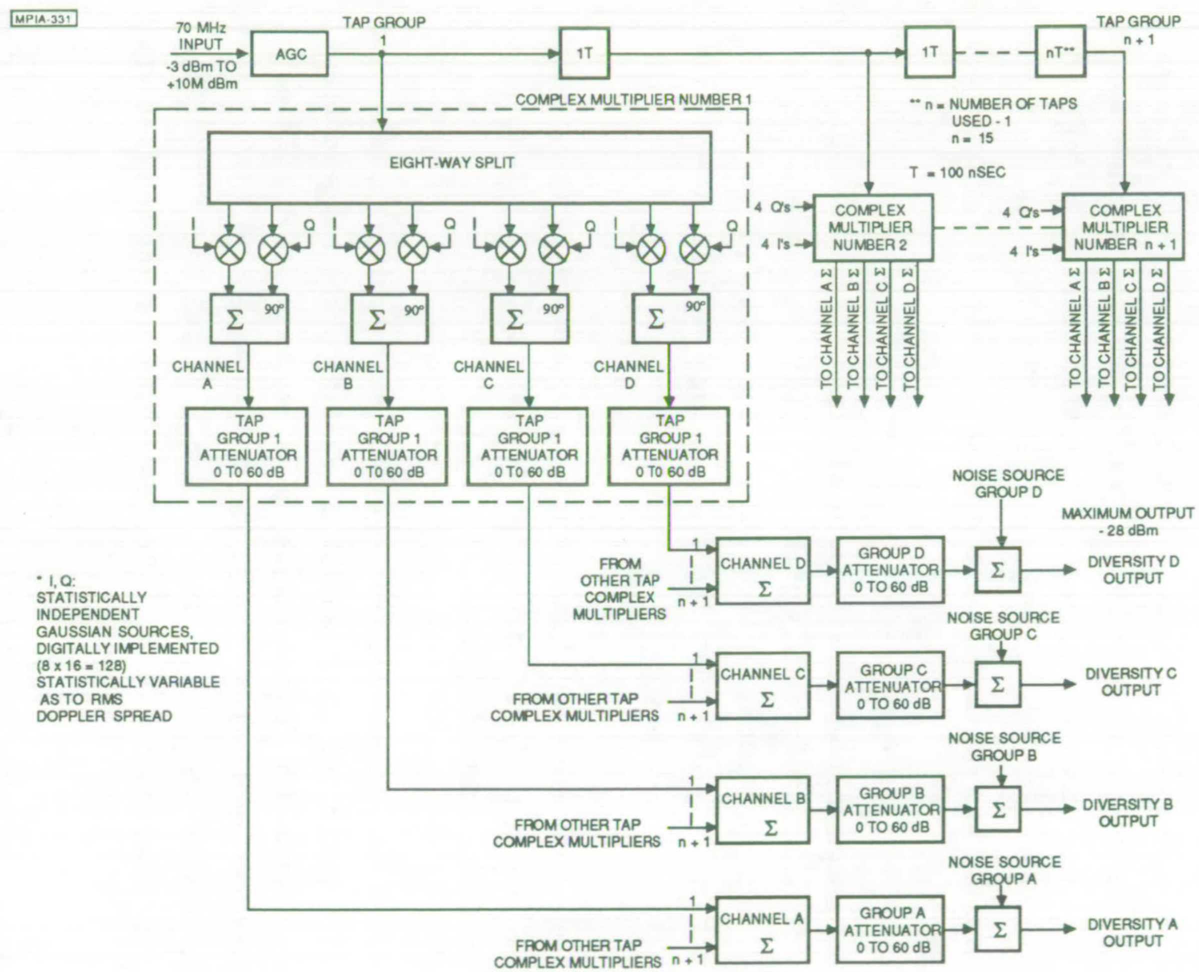

Figure 2.2. S-261C Dynamic Troposcatter Channel Simulator

Table 2-1. Multipath Profiles

Relative Attenuation, dB

Tap Number*	Profile 1 (P1)	Profile 2 (P2)	Profile 3 (P3)	Profile 4 (P4)
1	0	0	2	0
2		14	2	1
3		28	9	2
4			15	5
5			23	9
6			27	13
7				17
8				21
9				27
2σ (nanosecond)	0	41.3	153.2	270.
$2\sigma/\tau$	0	0.2	0.77	1.35

*Tap spacing = (100 nanoseconds) *Tap Number

Table 2-2. Test Equipment Requirements

1. HP3780A BER Test Set
2. HP11694A (2), 50Ω to 75Ω Impedance Transformer
3. HP8660C Synthesizer
4. Spectrum Analyzer HP8659
5. Oscilloscope TEK 2445
6. Counter HP5342A
7. Power Meter HP436A/Power Sensor 8484A
8. Polaroid Camera
9. HP3335 Synthesizer
10. 50 Terminators (2)
11. 75 Terminators (2)
12. Type N to BNC Adaptors (2)
13. HP8496B 10 dB Step Attenuator (1)
14. HP8494 1 dB Step Attenuator (1)
15. 22 dB Directional Coupler
16. HP355C Step Attenuator
17. HP355D Step Attenuator
18. Power Dividers (1)
19. 'T' Adapter
20. Directional Coupler HP11691

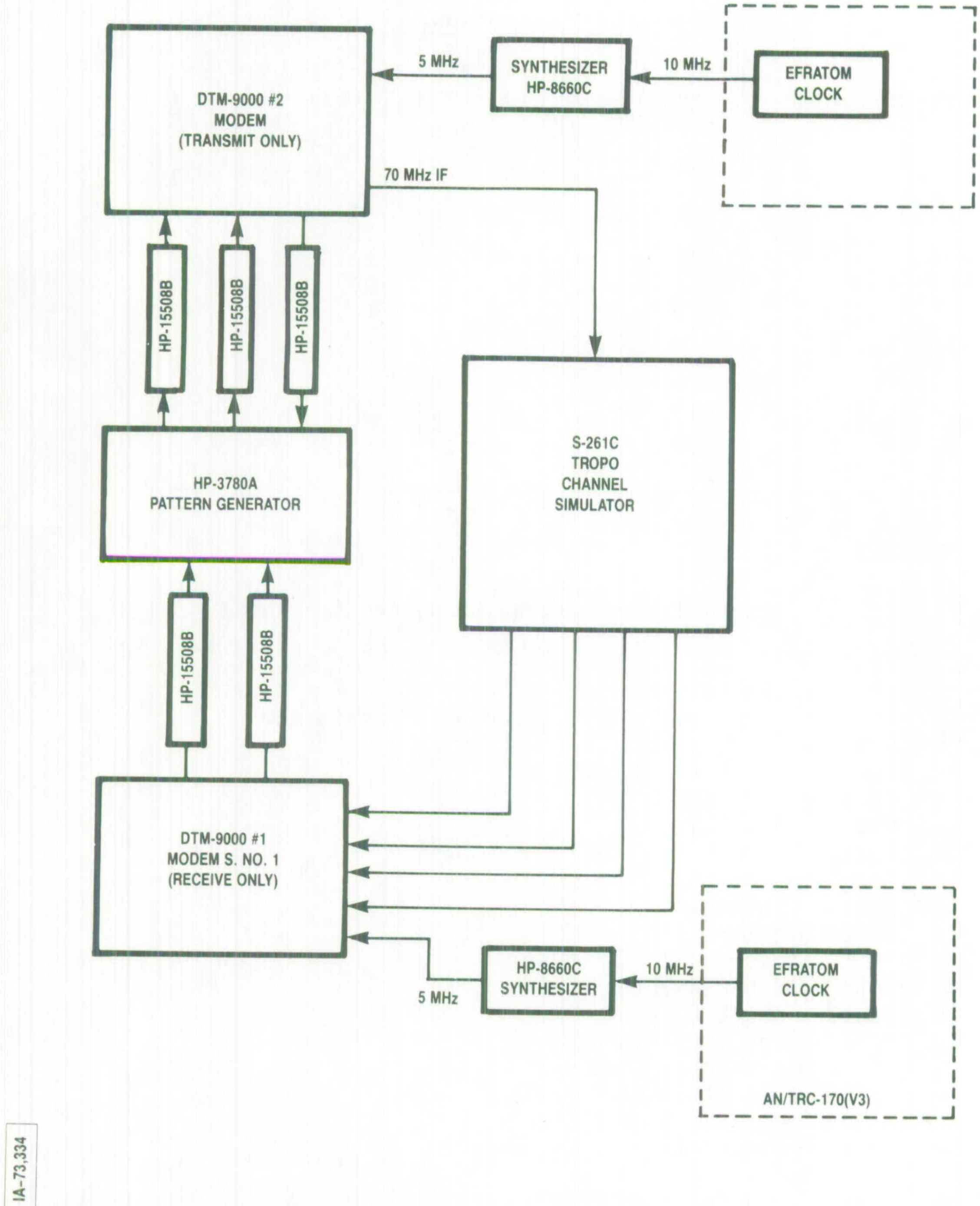

Figure 2.3. IF Loopback (Modem Back-to-Back) Tests With the Tropo Channel Simulator

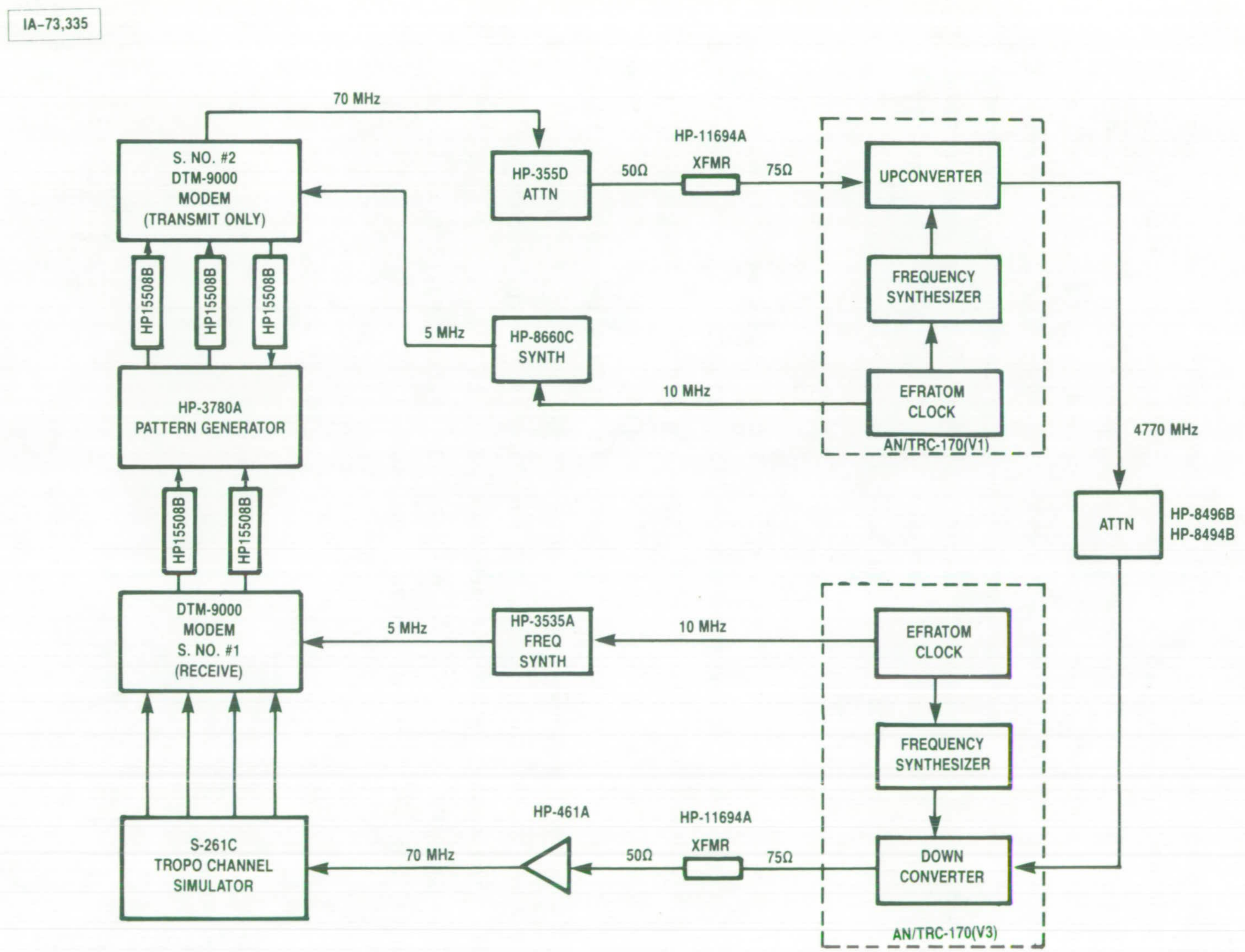

Figure 2.4. Upconverter/Downconverter Back-to-Back Tests

upconverter output (+27 dBm) was attenuated to -60 dBm to keep the Low Noise Amplifier (LNA) in the downconverter operating in the linear range. Care was also taken to reduce the ill-effects of leakage by properly terminating all unused outputs and operating at low signal levels, thus ensuring that leaking signals stay below the thermal noise of the downconverter. This was required because the transmit and receive functions were performed at the same frequency (4770 MHz). The same four multipath profiles ($2\sigma = 0$, 41.3, 153.2 and 270 nanoseconds) were used in evaluating the upconverter/downconverter performance.

The HPA effects on the terminal BER response were measured by performing tests using the test configuration as shown in figure 2.5. A 10 kW dummy load was used to terminate the HPA power. A portion of the HPA signal (55 dB below the HPA output) was used as an input to the downconverter. The signal level was maintained to approximately -60 dBm for linear LNA operation. BER tests were performed by using the same multipath profiles for consistency and for proper comparison. These tests were performed at power levels of 2.8 kW (1 dB below compression); 1.3 kW (4 dB below compression; HPA in linear range; and 5.0 kW (1 dB above compression).

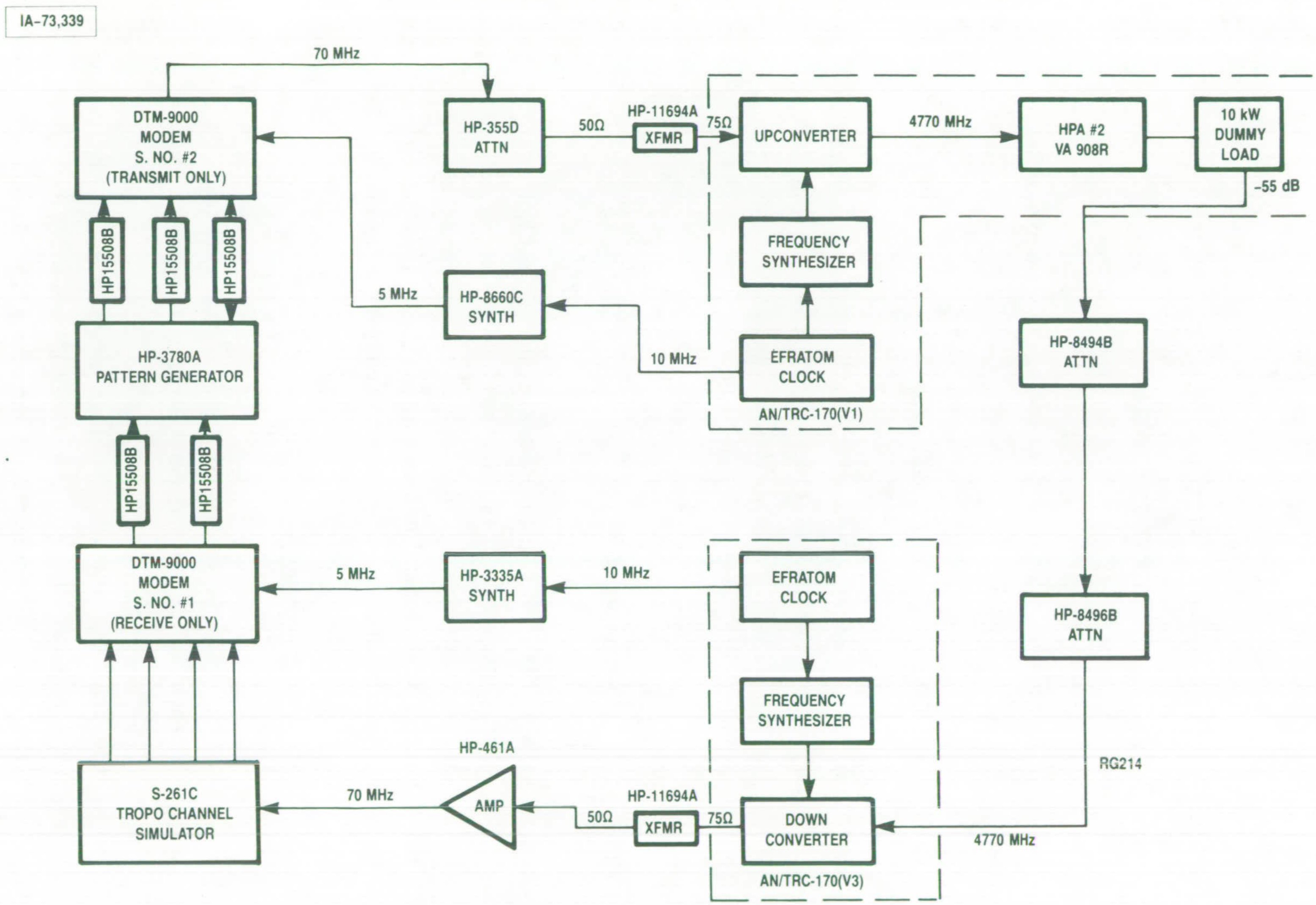

Figure 2.5. BER Tests Using C-Band HPA

SECTION 3

TEST PROCEDURES

The test procedures used for evaluating the terminals' performance are as follows.

3.1 PHASE I, INSTALLATION AND INTEGRATION

Installation and integration of the DTM-9000 modem with the AN/TRC-170 radios was performed prior to the start of the tests. Preliminary tests, including the self-test and back-to-back tests, were performed using standard test procedures.

3.2 PHASE II, BIT ERROR RATE TESTS

The interface test configurations are shown in figures 2.1 through 2.5. The test procedures for testing the modem in the back-to-back tests, the upconverter/downconverter, and the C-band (VA-908R) klystron are similar and hence only one test procedure, for the C-band klystron tests, is presented here for reference.

3.2.1 <u>BER Tests Using C-Band Klystron</u>

1. Configure the test equipment for testing terminal performance using the C-band klystron (figure 2.5).

2. Set the BER Test Set (HP3780A) to provide 9.696 Mb/s baseband digital data to the DTM-9000 modem. Verify that the modem is configured with the 10.5 MHz filter in the transmit section.

3. Verify that the output of the upconverter (RF driver power from the IPA to the HPA) has the proper drive level (+27 dBm max.).

4. Verify that the HPA power is set for the desired power level. Record voltage, beam current, and power levels of the HPA.

5. Adjust the RF attenuators (HP8494A and HP8496B) so that the downconverter output is in the -3 to +10 dBm range required by the S-261C simulator. This output is to be obtained without saturating the downconverter and amplifiers while maintaining an E_b/N_o of at least 30 dB. This will ensure that the measurements made with the simulator are based on calibrated noise levels established within the simulator alone while the data signals are subjected to the bandpass filter characteristics of the downconverter.

6. Set the simulator profile to setting 1 (ref. table 2-1) and fade rate to 10 Hz. Set E_b/N_o for 16 dB. Record the BER and number of readings. Compute the average bit error rate.

7. Repeat step 6 for E_b/N_o of 12, 8, and 4 dB.

8. Set the simulator profile to setting 2 (ref. table 2-1) and fade rate to 10 Hz. Set E_b/N_o to 16 dB. Record the BER and number of readings. Repeat step 7.

9. Repeat step 8 for the simulator profile to setting 3.

10. Repeat step 8 for the simulator profile setting 4.

11. Set the simulator setting to profile 3 and fade rate to 2 Hz. Set E_b/N_o to 16 dB. Record the BER and number of readings.

12. Repeat for E_b/N_o of 12, 8, and 4 dB.

3.3 PHASE III, AN/TRC-170 RADIO COMPONENT TESTING

The tuning range frequency response test and the phase response test of the AN/TRC-170 upconverter/downconverter were performed using various test procedures.

SECTION 4

SYSTEM LEVEL PERFORMANCE

4.1 THEORETICAL PERFORMANCE OF DIFFERENTIALLY ENCODED QPSK, FLAT FADING, QUAD DIVERSITY

The DTM-9000 modem utilizes differentially encoded quadrature phase shift-key (DEQPSK) modulation techniques for encoding the data. Probability of error for a DEQPSK modulation is twice that of the QPSK modem.

For a given $\bar{E}_b/N_o$, the probability of symbol error for the QPSK system is twice that of the Binary Phase Shift-Key (BPSK) system. However, since the symbol rate is one half the bit error rate of the BPSK system, the bit error rate is the same for a modem which employs two QPSK channels (with symbol rate) and is the same as the bit error rate of a BPSK mode. Therefore,

$$P_e \text{ BPSK} = P_e \text{ QPSK}.$$

The average probability of error for a slow, nonselective Rayleigh Fading Channel, in the presence of a complex zero mean white Gaussian Noise, can be expressed as a function of $\bar{E}_b/N_o$. For an ideal PSK modem

$$P_e = \frac{1}{2}\left[1- \frac{1}{1+\sqrt{\dfrac{1}{\bar{E}_b/N_o}}}\right] \qquad 4\text{-}1$$

and for differentially coherent PSK, (DCPSK) the probability of error is

$$P_e = \frac{1}{2} \left[\frac{1}{1 + \bar{E}_b/N_o} \right] \qquad 4\text{-}2$$

For ideal coherent PSK modulation and Rayleigh fading, the probability of error for low error rates and high E_b/N_o with maximal ratio (m·r·) combining is

$$P_e = \frac{1}{2\sqrt{\pi}} \frac{1}{\left[\bar{E}_b/N_o\right]^M} \frac{(M-1/2)!}{M!}, \qquad 4\text{-}3$$

where M is the order of diversity.

For quad diversity (M=4), this expression approximates to

$$P_e = 0.1367 \left[\frac{1}{\bar{E}_b/N_o}\right]^4 \qquad 4\text{-}4$$

for low error rates (high $\bar{E}_b/N_o$).

Since the probability of error for the DEQPSK mode (for the Rayleigh Fading Channel) is twice that of ideal PSK, for quad diversity, DEQPSK maximal ratio combining channel

$$P_e = 0.2734 \left[\frac{1}{\bar{E}_b/N_o}\right]^4 \qquad 4\text{-}5$$

For a quad diversity mode, using maximal ratio combining technique, the average error rate for differentially coherent PSK is

$$P_{e_{m \cdot r \cdot}} = \frac{1}{2} \prod_{k=1}^{k4} \left[\frac{1}{1 + \overline{E}_b/N_{o_K}} \right] \qquad 4\text{-}6$$

for equal $\overline{E}_b/N_o$ for all channels

$$P_{e_{m \cdot r \cdot}} = \frac{1}{2} \left[\frac{1}{1 + \overline{E}_b/N_o} \right]^4 \qquad 4\text{-}7$$

These equations are plotted in figure 4.1.

The curves serve as a baseline for comparing with the measured terminal performance.

4.2 MEASURED PERFORMANCE

Terminal performance was measured in terms of bit error rate for various segments of the terminal (e.g., modem loopback, upconverter/downconverter loopback, and at various HPA power levels). The bit error rate measurements were performed for fading channels representing four multipath profiles at modem loopback (70 MHz IF), upconverter/downconverter loopback (4770 MHz), and HPA power outputs at 4770 MHz (1.3 kW, 2.8 kW, and 5.0 kW). The bit error rates were measured at 1- to 2-minute intervals. Ten to fifteen BER data points (total time 15 minutes or less) were recorded for a particular $\overline{E}_b/N_o$ ratio. An average BER was calculated using these data points.

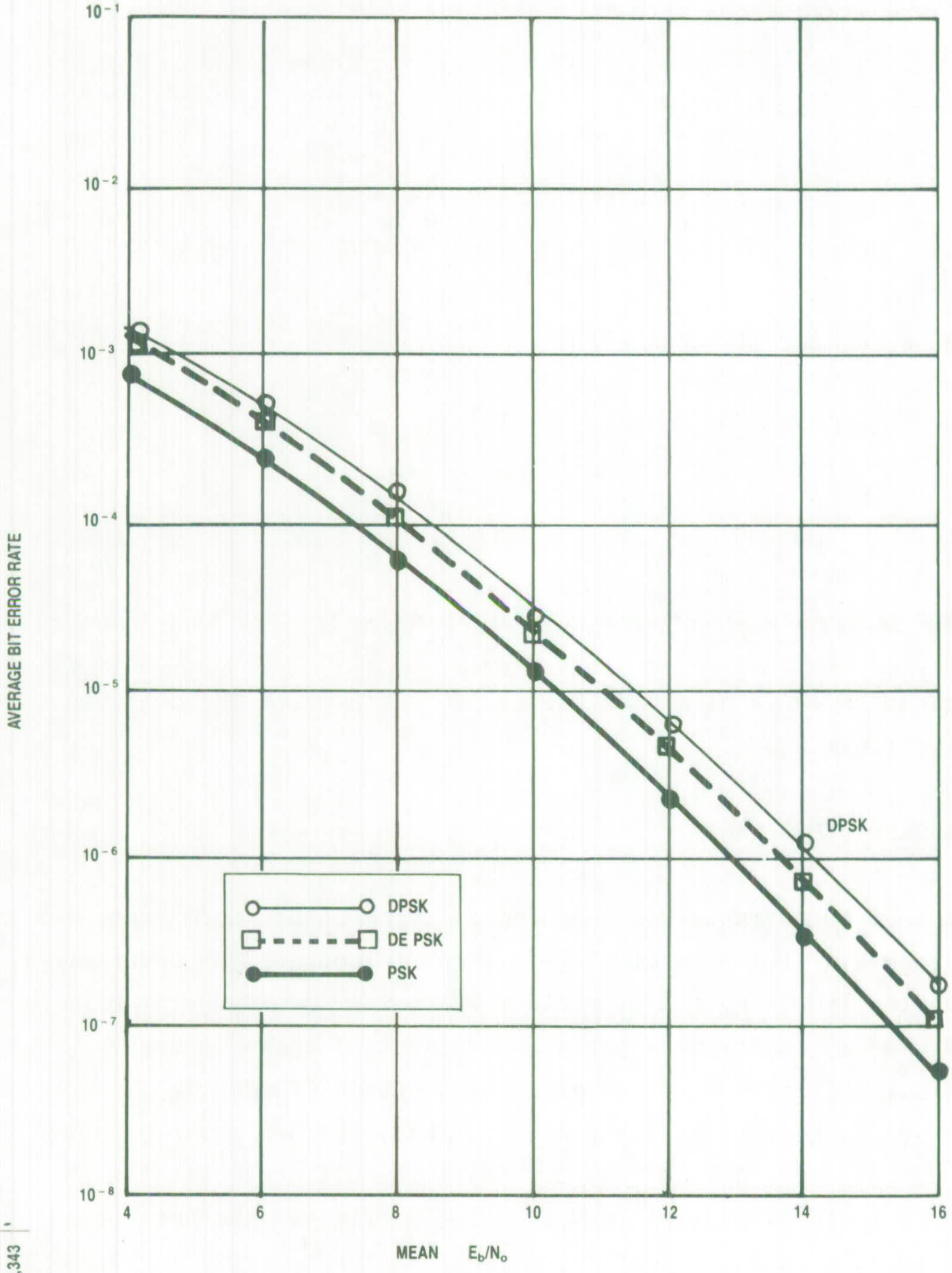

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Figure 4.1. Theoretical Performance of Different Modulation Schemes, Flat Fading, Quad Diversity

Scattering of the BER data points for a particular $\overline{E}_b/N_o$ (similar to figure 4.2) was observed during the testing process. This scattering of measured data points is primarily due to the relatively short integration times used (3 minutes maximum for lower bit error rates).

Integration times are important in making measurements because a troposcatter channel is modeled as a linear time varying channel, whose average multipath properties are given by the power impulse response. Hence, the scatter (variations) in the test points will be reduced if longer integration times are used.

The shorter integration times for these tests were necessitated by the schedule for availability of the tropo channel simulator and the AN/TRC-170 hardware. Data taken for each E_b/N_o for 15-minute samples of data using a similar modem (MD-918), suggests that there will be scattering of data points for each consecutive 15-minute (5 times longer than the DTM-9000, AN/TRC-170 integration times) sample of data. The measured dispersion of data is presented in figure 4.2. As seen from this figure, the dispersion is higher at lower bit error rates. At lower bit error rates, one may require relatively longer integration times (approximately 2 hours) to reduce the scatter in the data points.

4.2.1 Terminal Response for Flat Fading

The performance of the DTM-9000 interface with the AN/TRC-170 radio component is summarized in figure 4.3. As seen in the figure, the IF loopback curve closely follows the theoretical curve for all bit error rates.

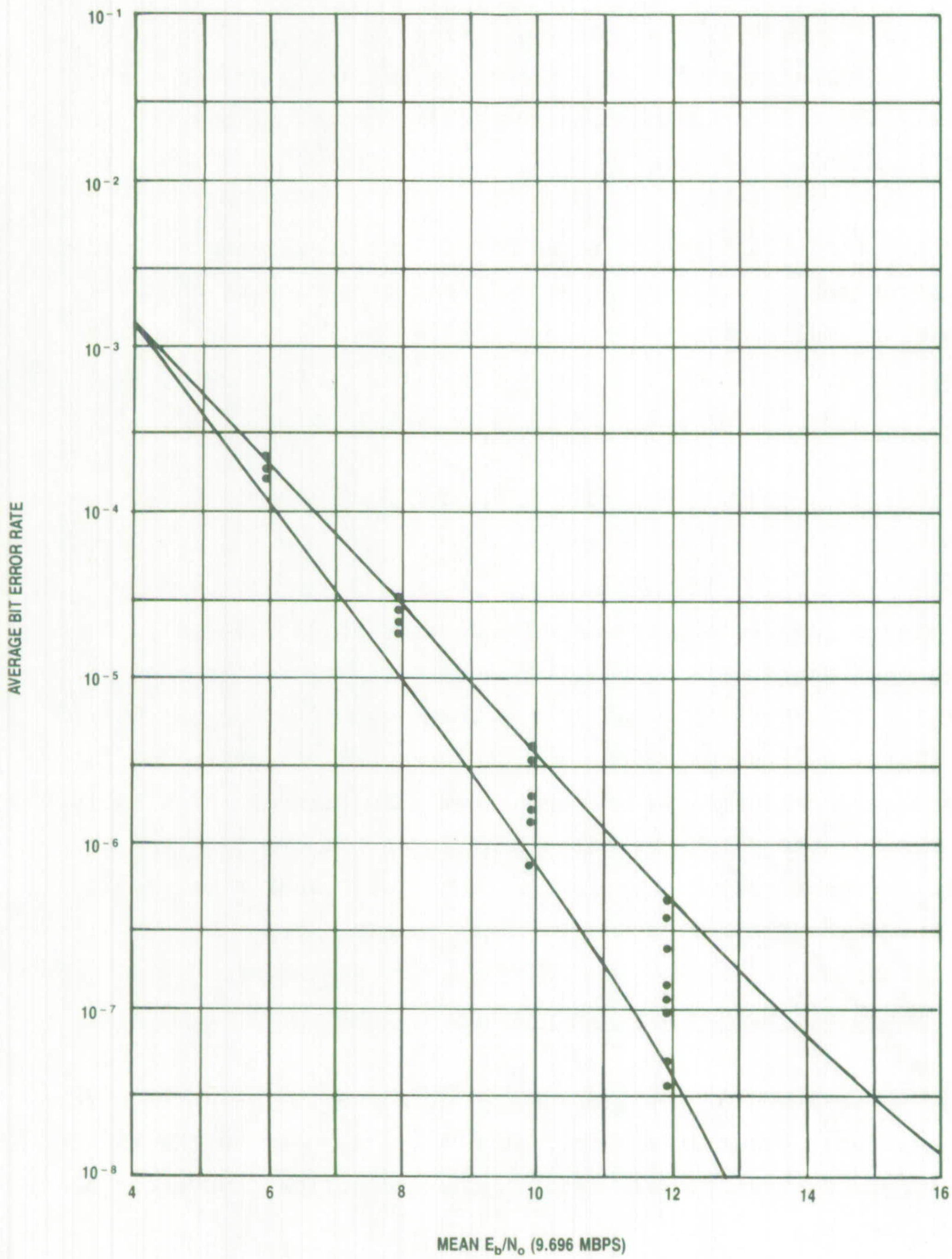

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Figure 4.2. Dispersion of Data Based on Measurements of 15-Minute Samples for MD-918/GRC Modem

The degradation in the terminal response at higher power levels is due to the nonlinearities introduced by the HPA (intermod distortion, phase nonlinearity, etc.). Note that at higher bit error rates, all curves tend to approximate each other because the nonlinearities introduced by the HPA are not a controlling factor in these measurements. In summary, the DTM-9000 interfaced with the AN/TRC-170 radio components very well under flat fading simulation conditions.

4.2.2 2σ Delay Multipath Spread of 41.3 Nanoseconds

The BER performance of the DTM-9000 interface with the AN/TRC-170 modem for the Channel Simulator Profile P2 (2σ = 41.3 nseconds, $2\sigma/\tau$ = 0.2) is presented in figure 4.4. The test configuration and test conditions are similar to those described for figure 2.4. There is approximately 1 dB improvement in the modem loopback performance when compared to the flat fading configuration. This is due to the modem implicit diversity gain. As seen from figure 4.4, the greatest degradation, compared to modem loopback (at 10^{-5} BER), is less than 1 dB, which occurs when the HPA is set up to deliver 5.0 kW (near saturation). The upconverter/downconverter loopbacks and HPA loopbacks (1.3 kW, 2.8 kW, 5.0 kW) will degrade the BER performance compared to the IF loopback (70 MHz) very slightly. Note that the dispersion of the data points are within the bounds as described in figure 4.2.

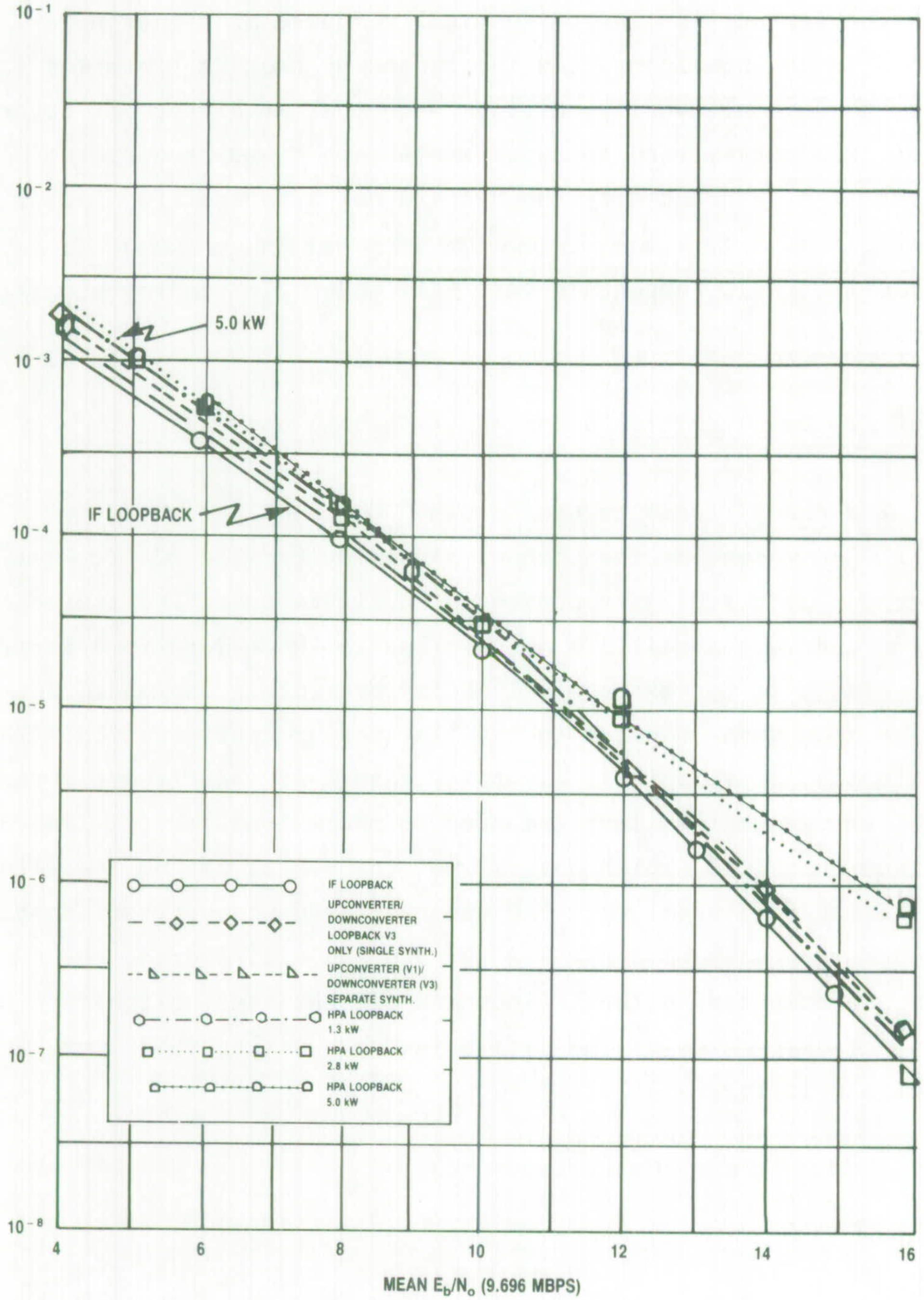

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Figure 4.3. Performance of DTM-9000 AN/TRC-170 Interface for Tropo Channel Simulator Profile P1, Flat Fading, Data Rate 9.696 Mbps, 10.5 MHz XMIT Filter, C-Band

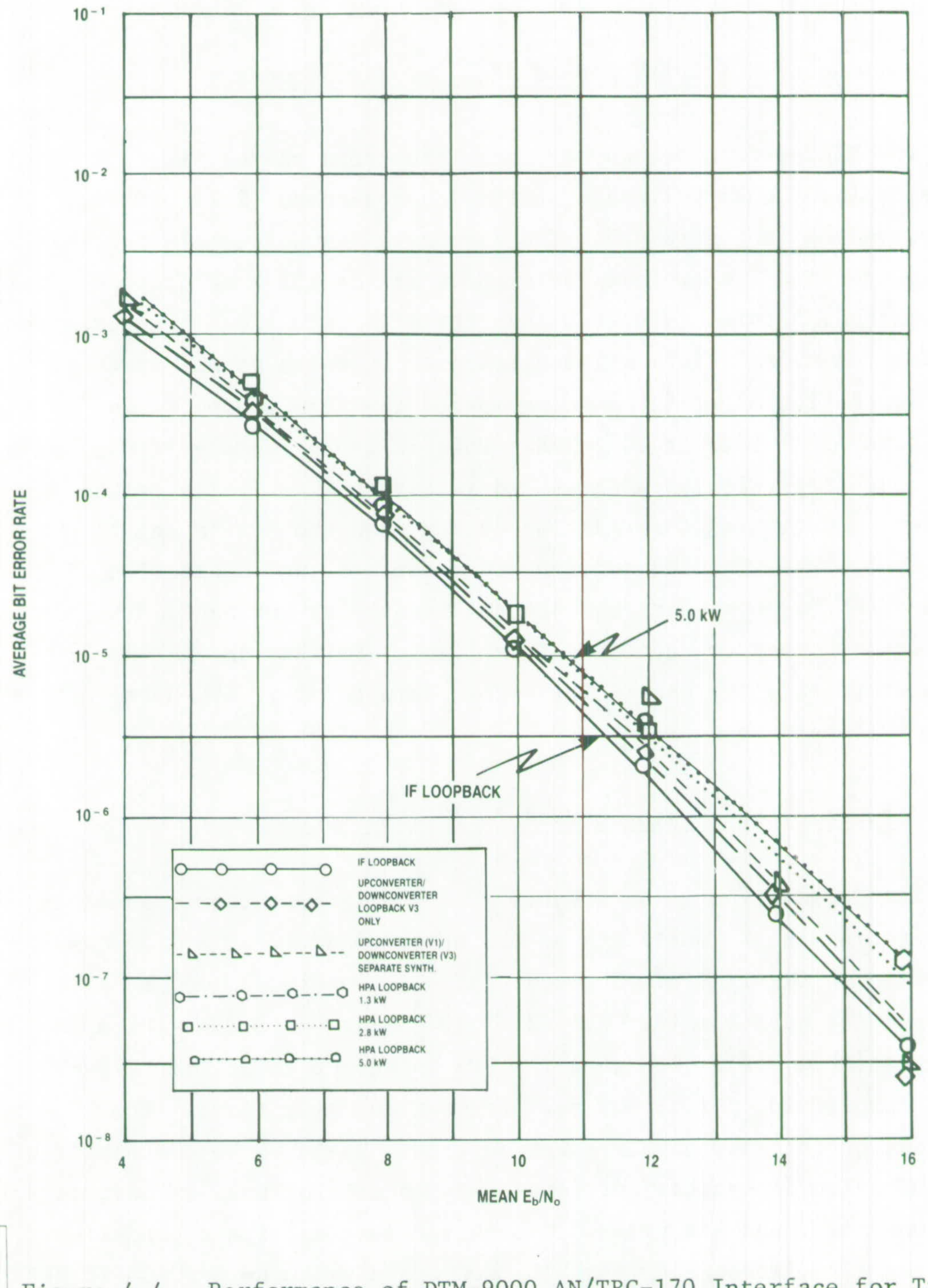

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Figure 4.4. Performance of DTM-9000 AN/TRC-170 Interface for Tropo Channel Simulator Profile P2, 2σ = 41.3 nsec, Data Rate 9.696 Mbps, 10.5 MHz XMIT Filter, C-Band

4.2.3 2σ Delay Multipath Spread of 153.2 Nanoseconds

The BER performance curves, when the tropo channel is experiencing the 2σ multipath of 153.2 nanoseconds ($2\sigma/\tau = 0.74$), are presented in figure 4.5. The dispersion is noticeable for this configuration. The overall performance at the 153.2 nanosecond multipath dispersion is better than the 41.3 nanosecond configuration because the modem offers higher implicit diversity gain. However, the degradation of performance, compared to modem loopback, is approximately 1.5 dB at 10^{-5} BER. This is approximately 5/10 of a dB more than dispersion data presented in figure 4.4. As described earlier, the greatest degradation occurs when the HPA is set to deliver 5.0 kW. The degradation may be due to the combination of upconverter/downconverter and HPA nonlinearities and bandwidth constraints. One can conclude from figure 4.5 that the AN/TRC-170 radio components are usable for higher data rates (9.696 Mbps) at these multipath conditions.

4.2.4 2σ Delay Multipath Spread of 270 Nanoseconds

The degradation is noticeable when the troposcatter channel is experiencing the 2σ multipath of 270 nanoseconds ($2\sigma/\tau = 1.31$) as indicated in figure 4.6. The degradation, compared to modem loopback, is approximately 2.5 dB at 10^{-5} BER. Note that there is no appreciable difference when the HPA is set up to deliver 2.8 kW (1 dB compression point) and 5 kW (closer to saturation). The degradation for this higher power multipath seems to be the result of a combination of synthesizer (frequency uncertainties), upconverter/ downconverter, and HPA effects. Even for this multipath condition, it looks like interfacing the DTM-9000 modem with the AN/TRC-170 RF

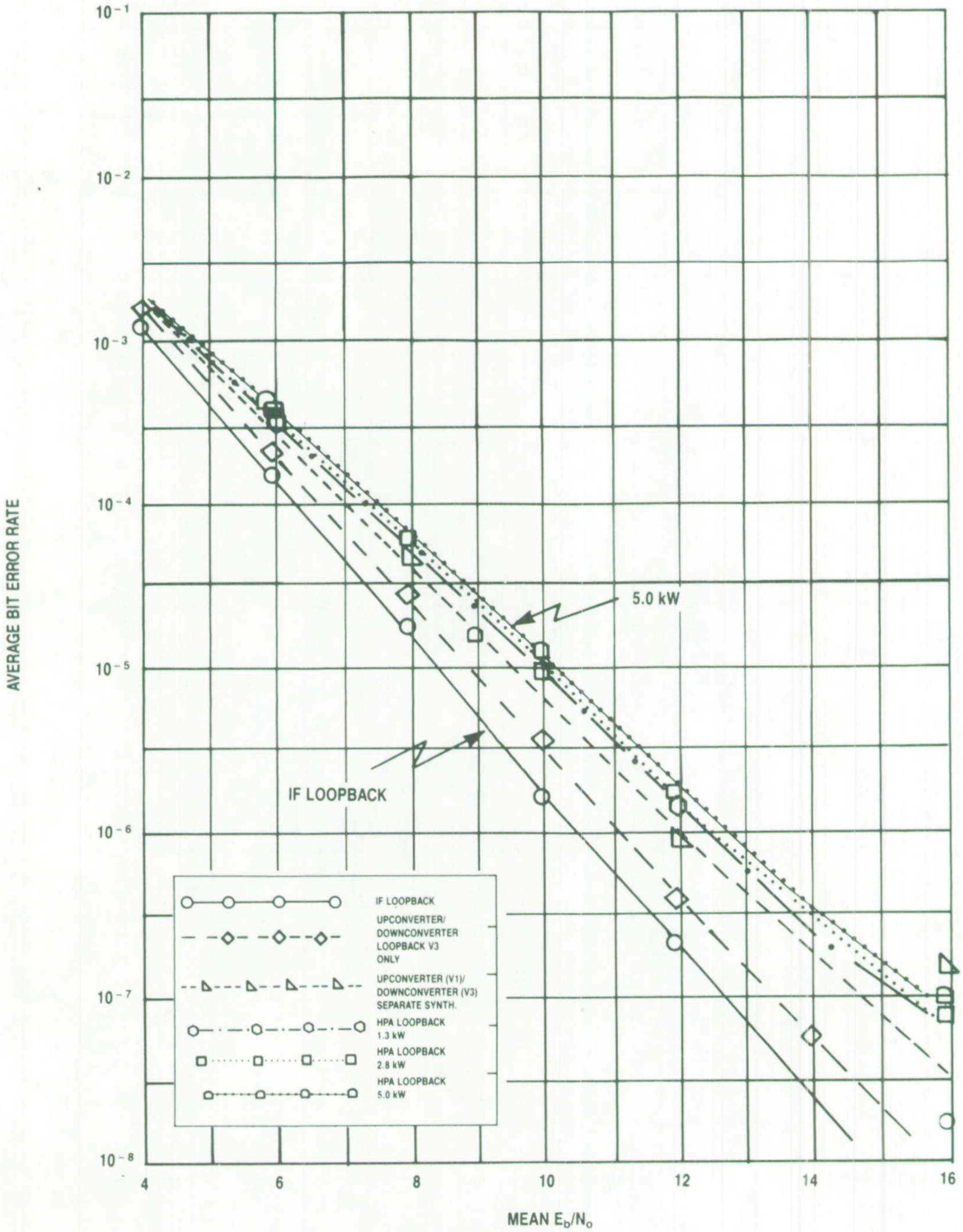

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Figure 4.5. Performance of DTM-9000 AN/TRC-170 Interface for Tropo Channel Simulator Profile P3, 2σ = 153.2 nsec, Data Rate 9.696 Mbps, 10.5 MHz XMIT Filter, C-Band

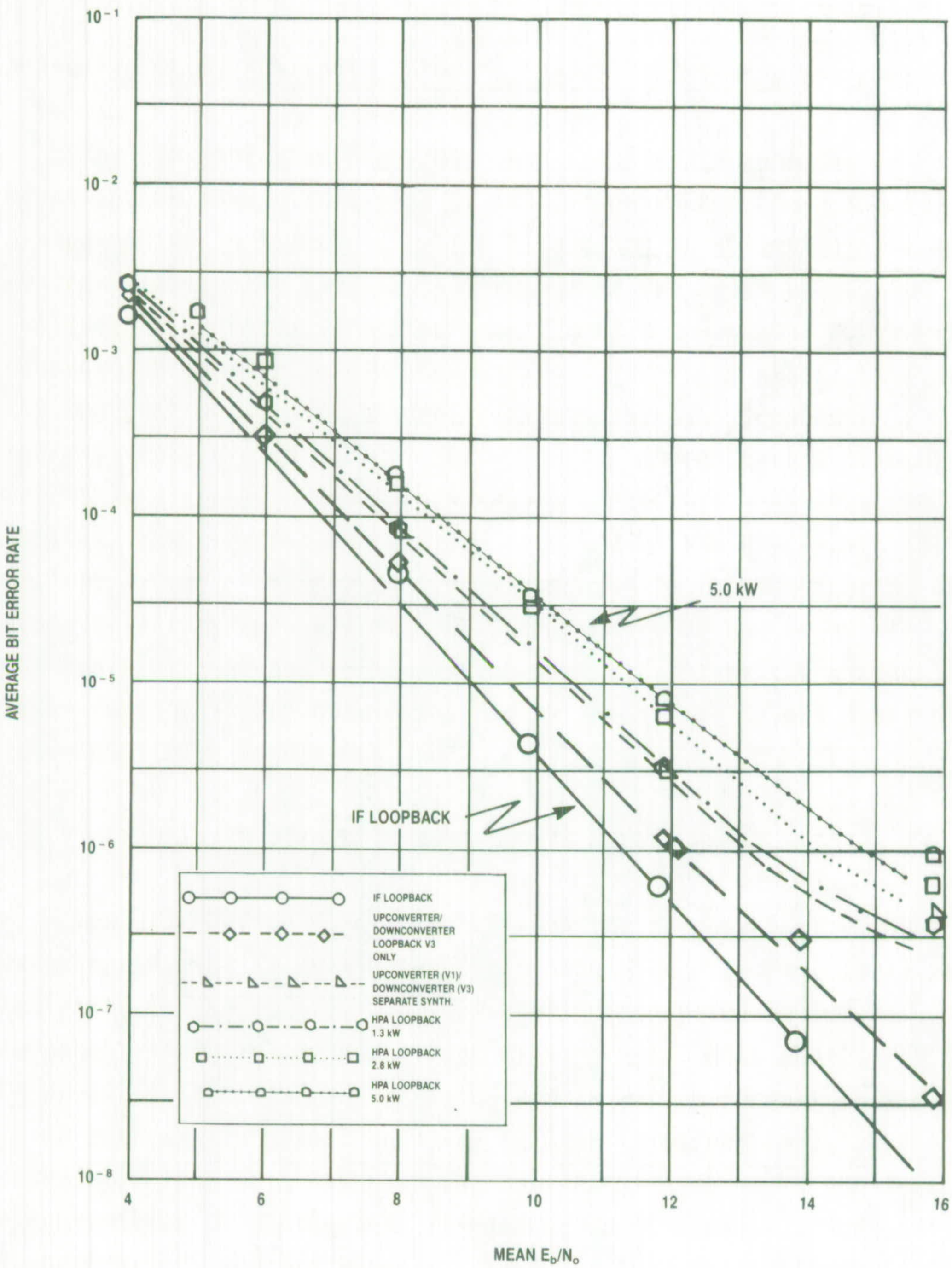

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Figure 4.6. Performance of DTM-9000 AN/TRC-170 Interface for Tropo Channel Simulator Profile P4, 2σ = 270 nsec, Data Rate 9.696 Mbps, 10.5 MHz XMIT Filter, C-Band

components is acceptable for the 9.696 Mbps mission bit rate. The BER performance may be improved by using improved radio components, however.

4.3 AN/TRC-170 RADIO COMPONENT TESTING

4.3.1 Upconverter Response

Extensive tests (frequency response, phase response, noise figure, etc.) were not performed on the upconverter and downconverter because of the limited time period. However, sweep response of the upconverter and HPA response tests were performed and are presented in figures 4.7 and 4.8. It seems from these figures that the upconverter bandwidth is above 15 MHz (more than the specified 1 dB bandwidth of 10 MHz). Also note that the limiting factor for the data transmission will be the HPA bandwidth whose sweep response indicates that this bandwidth is approximately 10 MHz.

4.3.2 Downconverter

Specific frequency and phase responses were not measured, again because of the limited time factor. However, DEQPSK spectral response through the downconverters taken during the tests is shown in figures 4.9 and 4.10. The spectrum response indicates that there is no visible distortion due to the bandwidth and phase constraints due to the downconverter.

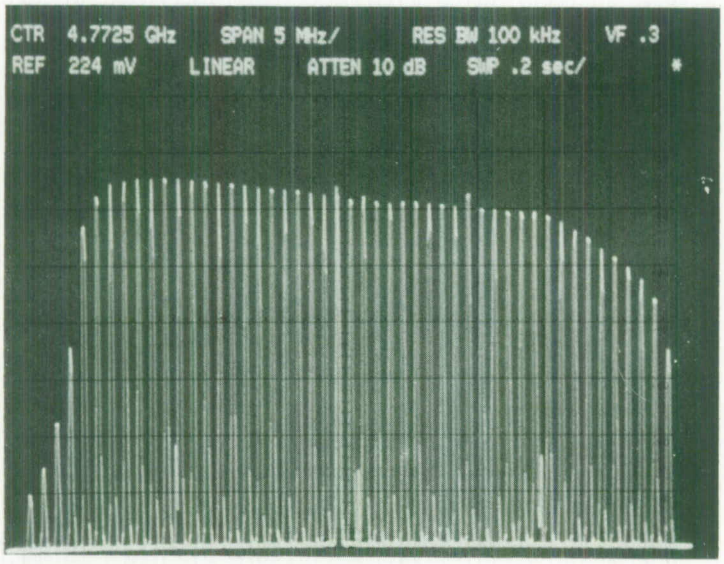

Figure 4-7. Upconverter (AN/TRC-170(V1)) Response

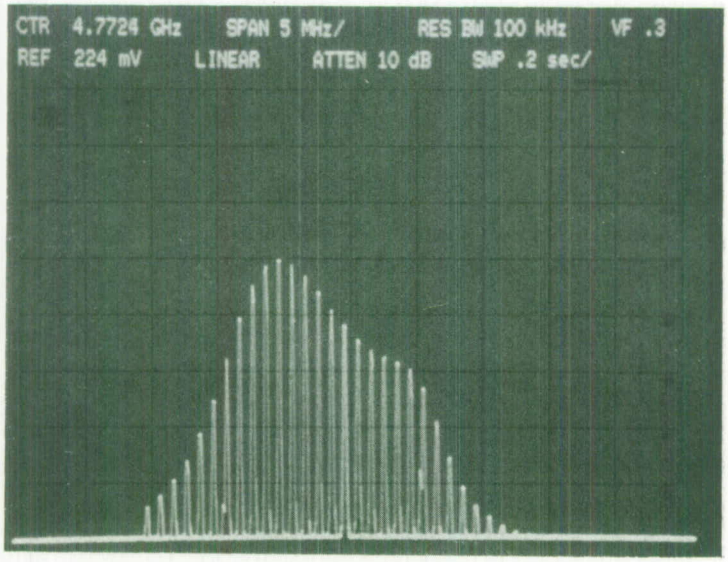

Figure 4-8. HPA (VA-908R) Response

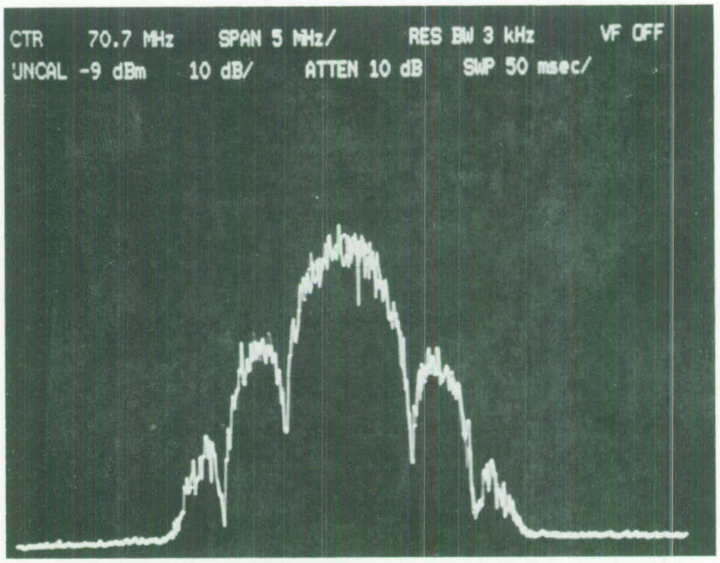

Figure 4-9. Output of the AN/TRC-170(V3) Downconverter

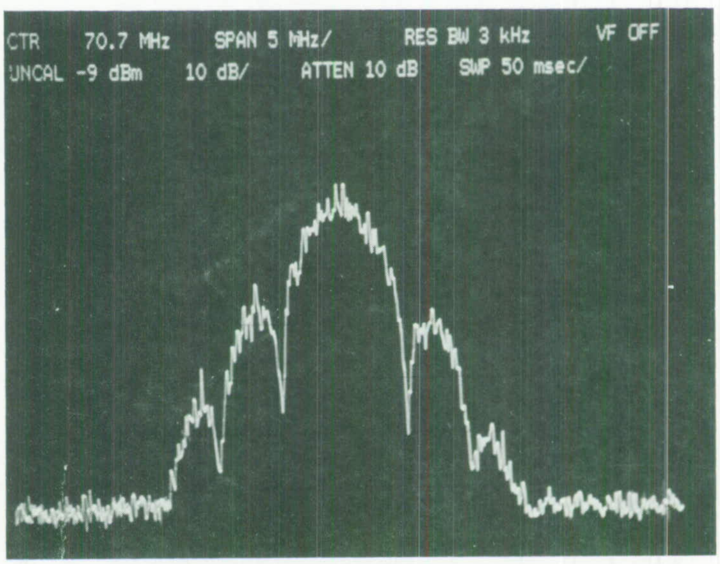

Figure 4-10. Input to the S-261C Tropo Channel Simulator

SECTION 5

CONCLUSIONS AND RECOMMENDATIONS

The BER performance tests indicate that the upconverter/ downconverter, and associated AN/TRC-170 equipment appear to be usable for the DEB program. These components did not degrade BER performance appreciably when compared to the performance of the IF loopback (i.e., loopback following the modem). There was a general consistency of performance when the BER tests were performed at both the output of the upconverter and the output of the VA-908R klystron amplifier for four multipath profiles.

It appears from these tests that one can use the VA-908R klystron for digital implementation if the required HPA power is less than 5 kW. However, if it is decided that more power is required, another HPA or klystron may have to be acquired for the DEB troposcatter terminals.

Note that these conclusions are based on testing the preproduction FSED version of AN/TRC-170 rf components. The production components (upconverters/downconverters, synthesizers) may differ in their performance compared to the FSED versions because of modifications made in becoming production versions; and conclusions may have to be revised accordingly.